Ridin' Herd

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Corn coproducts

Grain byproducts such as wheat mids, soy hulls and cottonseed hulls have been available for many years and have been used effectively in cow diets and supplements. More recent grain byproducts have come from the production of fructose (wet or dry corn gluten feed) or ethanol (wet or dry distillers' grains). Corn grain coproducts, especially distillers' grain, will be more abundant because of the number of ethanol plants being built in the Plains states. Research is being conducted using corn grain coproducts, and they appear to fit well in beef cow diets.

Dry-milling process

In the dry-milling (see Fig. 1) industry, the feed products that are produced are distillers' grains, distillers' grains plus solubles and distillers' solubles. Depending on the plant and whether producing wet or dry feed, the relative amounts of distillers' grains and distillers' solubles that are mixed together vary.

Distillers' solubles can be partially dried to form condensed distillers' solubles. The condensed distillers' solubles can be added to the wet grains in varying proportions to yield a product known as wet distillers' grains plus solubles.

Approximately one-third of the dry matter (DM) remains as the feed product following starch fermentation. As a result of this process, the nutrient content of the remaining residue after the extraction of the starch is increased threefold, because most grains contain approximately two-thirds starch. As an example, corn grain is typically 4% oil or fat; wet or dry distillers' grains are about 12% fat (on a DM basis). Distillers' grains can also be marketed as a dry product (87%-91% DM), with or without the addition of distillers' solubles.

Wet-milling process

The wet-milling industry (see Fig. 2) is more complex, because the corn kernel is divided into more components. For example, the oil is extracted from the corn and sold as corn oil. The importance of understanding the process is that the resulting feed products from these two industries are quite different based on how they are produced.

The wet-milling industry also has more restrictions in terms of grain quality and is limited to corn. The primary goal of wet milling corn is fractionation of the kernel. The distinct advantage over dry milling is that it yields a cornstarch slurry of high purity. In addition, a number of products could potentially be for human use. Only U.S. No. 1 or No. 2 Grade corn can be used in the United States.

In the wet-milling process, shelled corn is initially screened to remove crop residues, fines and broken kernels. The cleaned grain is then steeped in a dilute sulfurous dioxide solution for 40-48 hours. Steeping softens the grain to facilitate grinding, removes soluble materials and makes the starch fraction more available by disrupting the surrounding protein matrix. The kernel is then fractionated using a combination of grinding, differential separation and centrifugation. The various fractions isolated as an approximate percentage of the original corn grain include starch (68.0%), bran (12.0%), germ (7.5%), steep liquor (6.5%) and gluten (5.6%), with the remaining portion (0.04%) representing losses of volatile materials or other inefficiencies. The starch fraction is converted to dextrose, and dextrose can be converted to high-fructose sweetener, converted to ethanol via microbial yeast fermentation, or converted to plastics and other products.

Distillers' solubles are the byproduct of fuel ethanol production in the wet-milling process. This product contains yeast cells and residual sugars. Distillers' solubles arising from the wet-milling process differ from those produced by dry milling. Because the germ fraction is separated in the wet-milling process, wet-milling distillers' solubles contain low levels of fat.

Corn gluten feed is composed of steep liquor and corn bran, but may also contain germ meal, partial corn kernels and other ingredients. This varies from processing plant to processing plant depending on the plant's capabilities.

Variation with coproducts

The primary objective of the dry-milling process is to produce ethanol fuel. Because the resulting feedstuffs are secondary, they often can be quite variable in their nutrient content (see Table 1). A number of factors can affect the nutrient profile of distillers' grains, including moisture content, grain selection, the ratio of distillers' grains and distillers' solubles included in the product, and continuous vs. batch fermentation, as well as drying temperature and duration.

Moisture variation may pose the biggest challenge in managing wet byproducts. When 118 samples of dry distillers' grains plus solubles from 10 dry-milling plants in South Dakota and Minnesota from 1997 to 1999 were analyzed, samples averaged 88.3% DM, 28.2% crude protein (CP), 8.2% fat and 42.1% neutral detergent fiber (NDF). Coefficients of variation for across-plant means ranged from 1.7% for DM to 14.3% for NDF. Within a plant, the highest coefficient of variation for dry distillers'

Fig 1: Dry-milling process

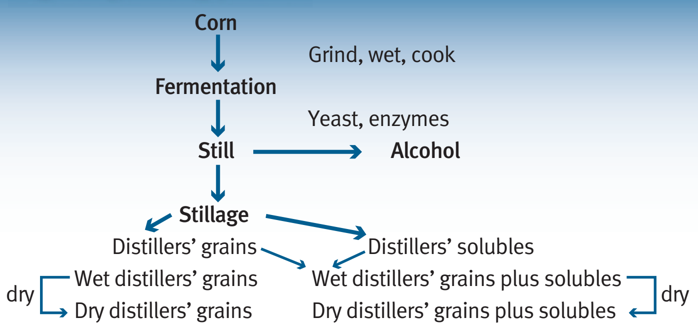

Fig 2: Wet-milling process

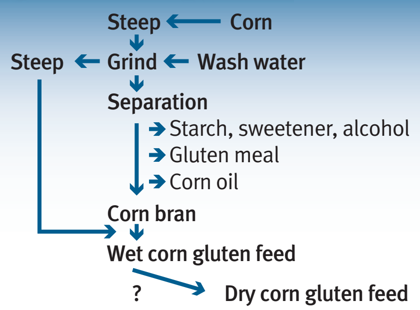

Table 1: Nutrient composition of selected corn milling byproducts.

Feedstuff:[a]	DRC[b]	WCGF-A	WCGF-B	DDGS[c]	WDGS[c]	CCDS[c]	MWDGS	Steep[d]
DM, %	90	44.7	60.0	90.4	34.9	35.5	45-50	49.4 (49.0)[e]
SD	0.88	0.89	0.05	1.7	3.6	1.4	NA	1.0 (0.58)[e]
CP, % of DM	9.8	19.5	24.0	33.9	31.0	23.8	NA	35.1
SD	1.1	0.63	0.51	1.3	0.9	1.5	NA	1.1
RUP, % of CP	60	20	20	65	65	65	NA	20
P, % of DM	0.32	0.66	0.99	0.51	0.84	1.72	NA	1.92
SD	0.04	0.03	0.04	0.08	0.06	0.27	NA	0.11
TDN, % of DM	90.0	90.0	94.5	101	112	112	NA	113
NE_g, Mcal/lb.	0.70	0.70	0.74	0.78	0.87	0.87	NA	0.88

[a]DRC=dry-rolled corn with National Research Council (NRC, 1996) values, WCGF=wet corn gluten feed from two plants, DDGS=dried distillers' grains + solubles, WDGS=wet distillers' grains + solubles, CCDS=condensed corn distillers' solubles (corn syrup), MWDGS=modified wet distillers' grains + solubles, steep is steep liquor from wet-milling plants, DM=dry matter, SD=standard deviation, CP=crude protein, RUP=rumen undegradable protein, TDN=total digestible nutrients, NA=not available.

[b]DRC values based on NRC (1996), with approximately 3,500 samples.

[c]Values are from spring 2003 from only one plant in Nebraska that produces DDGS, WDGS, and CCDS with standard deviation based on weekly composites.

[d]DM values are present variation from daily composites for a 60-day period. Other nutrients are based on monthly composites for 2002 and half of 2003.

[e]Values in parentheses are monthly composites for 2003 from one plant in Nebraska, with assumption that it is a mixture of steep and distillers solubles.

grains plus solubles dry matter was 2.0%. This is in contrast to the moisture consistency of wet distillers' grains plus solubles, which may have a 10% coefficient of variation within a plant. Compared to distillers' grains, condensed distillers' solubles contain more CP and lipid, with less NDF. The relative inconsistency of wet distillers' grains plus solubles may be due to more variation in the amount of distillers' solubles that wet grains can accommodate compared to dry grain.

In addition to the variation related to grain source, the nutrient content of the end product will depend on the ratio of grains and solubles in the wet or dry mixture. Facilities that dry the grains prior to adding solubles are capable of getting more solubles to stay in the mixture. However, maintaining separate products to dry the grains adds expense; therefore, the wet products are often combined, resulting in a lower proportion of solubles in the resulting distillers' dried grains plus solubles.

In traditional dry milling, not all the solubles can be held by the wet distillers' grains; therefore, some solubles must be marketed separately as condensed distillers' solubles, also known as corn syrup. Therefore, it is probably important to remember to get a feed analysis that includes moisture content and other nutrients. However, most of the variation is in the amount of moisture in the wet product.

Moisture is critical when evaluating price, so when comparing grain coproducts with other possible feeds that fit the cow herd's nutritional needs, convert to a DM basis and evaluate nutrients on a price per pound of nutrient basis. The data would suggest that the wet coproduct feed is better in terms of energy compared to the dried product, but managing a feed with a high moisture content is a challenge.

Let's look at feed composition.

Distillers' grains

Corn is two-thirds starch, and the starch is removed during alcohol production. The remaining nutrients are increased threefold compared to corn; therefore, distillers' grains contain 28%-30% CP [35% of the protein is degraded intake protein (DIP) and 65% of the protein bypasses the rumen as undegraded intake protein (UIP)], 11%-12% fat (oil), 40%-45% NDF and 0.8%-0.9% phosphorus (P). Distillers' grains are excellent sources of protein, mostly UIP (see Table 2).

Excessive heating of protein sources can result in the formation of acid detergent insoluble nitrogen (ADIN), which renders protein unavailable to the animal. This has been a concern with products of the dry-milling industry. However, in trials using growing calves fed either wet or dry distillers' grains in forage diets, performance was not different. In addition, when feeding dried distillers' grains plus solubles that varied in ADIN, performance was not different.

As an energy source in feedlot diets, the energy value is 120%-150% of the value of dry-rolled corn. The higher values appear to be due to acidosis control. In addition, recent research by Loy et al. (2004) suggests that wet and dry distillers' grains have an energy value 120%-127% that of dry-rolled corn in forage diets. As a commodity, distillers' grains can be fed as a protein or phosphorus supplement or as an energy/fat supplement. Degradable protein supplementation appears unnecessary with feeding distillers' grains if sufficient metabolizable protein is fed.

NDF is three times higher in distillers' grains than in corn grain. In fact, the NDF content of distillers' grains is much like that of a forage; however, this fiber fraction in grain coproducts is very digestible — unlike the NDF in many forages. In addition, because the starch is removed in the process, distillers' grains are digested in very much the same way that forages are digested in the rumen. This basically means that the rumen microbial population doesn't change much when distillers' grains are added to high-forage diets, because the microbes that digest distillers' grains also digest forage.

The result is a high-energy fiber source that has no negative associative effects on fiber digestion. These characteristics make distillers' grains a very attractive supplement in cow diets. Dry distillers' grains are typically 90% DM, and wet distillers' grains will be between 35% and 50% DM, depending on the plant.

Corn gluten feed

Again, corn gluten feed is a byproduct of the wet-milling process. Wet or dry corn gluten feed is an excellent feed for both the feedlot and cow-calf industry (see Table 2). In the process, the starch is removed and commonly made into sweetener (fructose).

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Table 2: Nutrient content (DM basis) of feeds[a]

Feed	%CP	%DIP	%UIP	%TDN
Corn	9.8	45	55	90
Distillers' grain	30.0	35	65	100-110
Wet corn gluten feed	23.8	80	20	90-98
Wheat midds	18.4	77	23	83

[a]Values from 1996 NRC.

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Like distillers' grains, the NDF content is much higher than corn. Therefore, corn gluten feed is digested similar to distillers' grains and forage in the rumen. The result is a high-energy fiber source that has no negative associative effects on fiber digestion.

Corn gluten feed is a good source of energy, protein and phosphorus. Corn gluten feed is between 19% and 24% CP, with 80% of the protein as DIP and 20% as UIP. This byproduct is also high in phosphorus (0.9%-1.1%) and sulfur (S, 0.47%). Corn gluten feed is about 3.9% fat.

Dry corn gluten feed is typically 90% DM and wet gluten is usually between 42% and 44% DM, but can be 60%.

Wet corn gluten feed is similar to or has a higher energy content (100%-110%) than corn grain, depending on the processor and how much steep is added. Dry corn gluten feed has a lower energy content than wet, meaning that in the drying process something happens that results in a reduction in energy.

Corn germ is the fraction containing the majority of the oil present in the original kernel. Whole germ contains 48% oil, 13% CP and 12% starch. Corn germ meal is the feed product resulting from the extraction of the oil from the germ fraction. Solvent-extracted germ meal may be around 10% DM and contain 25% CP and 1.5% oil. Germ meal may also be added to corn gluten feed, but usually is not.

Summary

Corn byproducts can be used for either protein supplementation or energy supplementation of backgrounding or heifer/cow diets. Considerable difference exists between wet-milling (corn gluten feed) and dry-milling (distillers' grains) byproducts in terms of nutritional value, primarily based on the process.

The energy value of wet distillers' grains is 125% or more the energy value of corn. Wet corn gluten feed varies from equal to or slightly higher (110%) energy than corn, depending on the amount of steep liquor. When dried, the energy value of gluten feed is reduced.

Both distillers' grains and corn gluten feed are good sources of protein. Corn gluten feed as a protein source is high in DIP and is a good source of nitrogen for rumen microbes. Distillers' grains as a protein source are high in UIP.

Both gluten and distillers' grains are good sources of phosphorus. Although both feeds are high in sulfur, neither feed will be fed at 100% of the diet.

Because both distillers' and gluten have positive associative effects when fed with forages, they appear to be good sources of either protein or energy for cow-calf operations. In addition, these corn byproducts generally alleviate acidosis in grain-feeding situations.

This sets the stage for the next article on how these feeds fit into a feeding program for cow-calf operations. In the Plains states, ethanol plants are being built and existing plants are expanding; therefore, the availability of specifically distillers' grains will increase. As a result, many universities are conducting research using these products.

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Editor's Note: *"Ridin' Herd" is a monthly column written by Rick Rasby, professor of animal science at the University of Nebraska. The column focuses on beef nutrition and its effects on performance and profitability.*